

THE ANNALS
AND
MAGAZINE OF NATURAL HISTORY.

[SECOND SERIES.]

No. 98. FEBRUARY 1856.

VIII.—*Notes on the Palæozoic Bivalved Entomostraca.* No. III.
Some Species of Leperditia. By T. RUPERT JONES, F.G.S.

[With two Plates.]

[Continued from vol. xvi. p. 176.]

IN Notes I. and II. ('Annals,' August and September 1855) I have described the little *Beyrichia* of the Upper and Lower Silurian rocks, especially of Sweden and Britain; in this paper I propose to describe other small Bivalved Entomostracan Crustaceans, larger than the former, and characteristically distinct. These are from the Silurian rocks of Scandinavia, Russia, Arctic America, and England; except one which is from the Devonian rocks of Normandy*.

Two little fossil bivalves † from the palæozoic rocks of Gothland were figured and described more than twenty years ago by Hisinger ‡, who recognized their general dissimilarity to the Conchifera, and referred them to the Entomostracan genus *Cythere*, which was the only marine bivalved form of the Subclass of the Crustacea at that time known to naturalists §.

* I have also seen lately a typical *Leperditia* from the Carboniferous Limestone of Tournay, Belgium.

† *Cytherina Balthica* and *C. phaseolus*. It is only of the former that I can here speak,—as I have not yet obtained any specimen referable to the latter. Klöden's *Cytherina phaseolus* (Verst. Mark Brandenburg, p. 102. pl. 1. fig. 10) appears to be a distinct form, of great interest. M'Coy has referred to *C. phaseolus* some Irish Silurian specimens; but Mr. Salter assures me that they do not correspond.

‡ In his 'Anteckningar i Physik och Geognosi under resor uti Sverige och Norge;' and also in his 'Lethæa Suecica.'

§ O. F. Müller's Notes in the 'Philos. Trans.' 1771, and his elaborate work on the "Entomostraca," published in 1785, and again in 1792, were still the chief sources of information on this subject.

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Later researches, however, have greatly extended the list of the Entomostraca; and there are several well-known existing forms which possess a bivalved carapace or shell; such as *Cypris*, *Cythere*, *Cypridina*, *Limnadia*, *Daphnia*, and *Nebalia*. In these the carapace is vertical, and its two lateral halves or valves are either distinct in themselves and united by a more or less elaborate dorsal hingement,—or form one entire shell, doubled along the back with a flexible fold. Other Entomostraca have the carapace horizontal and flattened, or nearly so, and marked by a mesial ridge or line along its greater axis;—as *Apus* and *Limulus*. Of the above-mentioned genera, nearly all have been presented in geologic times in forms more or less closely related to the existing species.

In the case of the fossil Entomostraca, the soft parts, including the maxillary, branchial, and locomotive organs, on which the generic and sometimes the specific distinctions of the recent forms are mainly established, have quite disappeared; and the hard carapace-valves alone remain to guide us in the recognition of genera and species. It is fortunate, however, that the families, and most of the genera even, of the existing Bivalved Entomostracans* have carapaces sufficiently characteristic to enable us to co-ordinate the fossil forms by the analogies presented in the form and structure of the valves.

For the most part, the Entomostracan bivalves, both from their minute size and in their general aspect, are strikingly different from the Conchifera. Some, however, as for instance the *Estheria donaciformis* †, may readily be mistaken for ordinary bivalve shells.

One of the two little Gothland fossils above mentioned, although it resembles the Conchifera in being bivalved and in its bean-shaped form, differs from Molluscan bivalves ‡ in general appearance, and in the combination of the following characters;—the great length of the hinge-margin,—the absence of umbos,—the extreme overlapping of one valve over the other on the ventral margin,—the uniform smoothness of the surface,

* When we refer to *minute distinctions of form, hingement, and ornamentation*, we find that among the recent Bivalved Entomostraca some families and even genera have carapaces peculiar to them (*Cypridina*, *Nebalia*, *Limnadia*); whilst in other families a nearly similar carapace belongs to two genera (*Cypris* and *Candona*,—*Daphnia* and *Lynceus*); and on the contrary even two characteristically different carapaces occur among the species of one genus (*Cythere* and its subgenus *Bairdia*).

† Proceed. Zool. Soc. 1849, vol. ii. p. 86. Pl. Annulos. 11.

‡ With respect to the characters in which there is an approach in form, viz. a straight hinge-line and an overlapping of one valve over the other, I have been favoured with the following note by my friend Mr. Pickering:—

“On looking over the recent Conchifera, or bivalve Mollusca, I do not

—the relative thickness and the horny aspect of the valves, which are marked moreover by a small tubercle, and by a central spot, formed by a local variation in the tissue of the test.

With these characters, it is readily recognized as a Crustacean; but with regard to the place of the Gothland fossil amongst its congeners, although the several characters above enumerated are individually represented by other Bivalved Entomostraca, yet there is no genus, either existing, or yet described from the tertiary or secondary rocks, to which this fossil can be referred. The genus *Beyrichia*, of the Silurian rocks, presents some special characters in common with the fossil in question; but the two forms are unmistakeably distinct*.

In the description of some fossils from the Devonian schist and limestone of Ille et Vilaine (Brittany), M. Rouault† in 1851 recognized two new Entomostracan bivalves—a *Beyrichia* (*B. Hardouiniana*‡, Rouault), and a form on which he founded the genus *Leperditia*. The generic characters of this Bretagne species (*L. Britannica*, Rouault) are clearly described, and are closely applicable to the Gothland fossil above referred to.

Through the kindness of Mr. J. Morris, I have had the opportunity of studying some very fine specimens of the Gothland form, as well as two valves from Néhou, which are referable

find, and indeed do not know of, any genus bearing the same characters united as in your Crustacean, namely a straight hinge-line and an overlapping ventral margin.

“The following genera show more or less one or other of these characters:—

<i>Solemya,</i>	}	a straight hinge-line.
<i>Lithodomus,</i>		
<i>Modiola,</i>		
<i>Mycetopus,</i>		
<i>Iridina,</i>		
<i>Arca,</i>		
<i>Meleagrina,</i>		
<i>Perna,</i>		
<i>Avicula,</i> inequivalve, with straight hinge-line.	}	an overlapping ventral margin.
<i>Potamomya,</i>		
<i>Azara,</i>		
<i>Corbula,</i>		
<i>Thracia,</i>		

“The dorsal margin of *Solemya*, with the ventral margin of *Potamomya*, would, I think, produce the form required, but such a form is unknown to me.”

* *Vide antea*, vol. xvi. pp. 91 & 174.

† *Bullet. Soc. Géol. France*, 2 sér. vol. viii. p. 377.

‡ This species was inadvertently overlooked when I was preparing the Table of the *Beyrichiæ*, *antea*, vol. xvi. p. 175.

I take this opportunity of correcting an *erratum* in the Table here referred to:—*B. Wilckensiana*, and its variety *plicata*, should be placed under the heading *Corrugatæ*, instead of under *Simplices*.

perhaps to M. Rouault's species. The British Museum and the Geological Society's Museum contain some highly interesting specimens from Gothland. Mr. Salter has submitted for my examination numerous specimens of *Leperditia* from the Silurian limestones of the Arctic Regions and elsewhere; and Mr. Woodward and other friends have favoured me with several others. These materials have enabled me to prepare a notice of a few principal forms of the genus, which, though closely related, have sufficient peculiarities of the carapace to render them specifically distinct.

Class CRUSTACEA.

Subclass ENTOMOSTRACA.

Order Phyllopoda?

Family LEPERDITIDÆ.

Genus LEPERDITIA, Rouault, 1851. *Bullet. Soc. Géol. France*, 2de série, tome viii. p. 377.

Generic characters.—Animal enclosed in a vertical bivalved carapace. Carapace inequivalved; somewhat resembling a tamarind-stone and other leguminaceous seeds. Carapace-valves smooth, convex, horny in appearance, nearly oblong, longer than broad*, bean-shaped, inequilateral, posterior half broadest; dorsal border straight; ventral border nearly semicircular; anterior and posterior borders oblique above, rounded below, the valve-margin passing from each end of the hinge-line in an oblique direction downwards and outwards to about half the breadth of the valve, where it meets the curved ends of the ventral border, and so forms the more or less angular extremities of the valve, the former of which is narrower and sharper than the latter.

Valves united along their upper (dorsal) borders by a simple linear hinge; the two extremities of the hinge-border form angles with the anterior and posterior borders in each valve.

The right valve larger than the left, being broader, and overlapping completely the ventral border of the opposite valve, and to some extent its anterior and posterior borders. The overlapping ventral border of the right valve forms a thick blunt keel to the closed carapace.

Each valve is somewhat depressed towards the dorsal border; this border in the left valve is thicker than that of the right, and sometimes slightly overrides it. The ventral margin of the left valve is turned suddenly inwards, forming a thin plate project-

* The length is measured in the direction of the hinge-line,—the breadth (or height) in that from the dorsal to the ventral margin.

ing into the cavity of the carapace. The line of junction of the inverted border, or ventral plate, and the outer surface of the valve is angular, and bears a slight sulcus and moulding, against which the overlapping edge of the right valve abuts. The dorsal or the ventral profile of the closed valves is elongate acute oval; the end view of the closed valves is more or less ovate.

Rather above and in front of the centre of each valve, and on its most convex portion, nearly all the species of the genus present a slightly raised, circular or suboval swelling, having a diameter of from $\frac{1}{5}$ th to $\frac{1}{4}$ th of the breadth of the valve's surface. This swelling is distinguishable by a local change of colour or of surface-condition, and marks the place of a corresponding rounded pit, excavated on the interior surface of the valve so deeply as to render the tissue of the valve at the swelling somewhat diaphanous. The cast of this pit on an inner cast of the valve is strongly marked, having a greater relative height than the external swelling. The swelling has usually a reticulated appearance resulting from vascular impressions on the test: and from a slight sulcus at the margin of the pit a set of delicate canals*, tortuous and inosculating, excavated on the interior of the valve, radiate forwards, downwards, and backwards, gradually becoming fainter towards the edges of the valves.

Anterior to the central tubercle, or "lucid spot," and nearer to the dorsal margin, is a smaller, but prominent, tubercle on each valve, with a corresponding internal pit. This little tubercle (the "anterior tubercle") is usually seated on or at the edge of a slightly raised area of irregular outline; and behind it a short shallow vertical sulcus, commencing at the dorsal margin, is usually apparent.

1. *Leperditia Balthica*, Hisinger, sp. Pl. VI. figs. 1-5.

Cytherina Balthica, Hisinger, Anteckningar i Phys. o. Geol. part 5. pl. 8. fig. 2; *Lethæa Suecica*, p. 10, 118. pl. 1. fig. 2 a, b, pl. 30. fig. 1.

Dimensions of closed or of separate valves of five individuals:—

Length. (inch)	Breadth. (inch)	Thickness. (inch)	
$\frac{20}{24}$	$\frac{13}{24}$	...	Right (broad) valve.
$\frac{19}{24}$	$\frac{11}{24}$	...	Cast of left (narrow) valve.
$\frac{17}{24}$	$\frac{10}{24}$	...	Left valve.
$\frac{15}{24}$	$\frac{10}{24}$	$\frac{6}{24}$	Perfect carapace.
$\frac{12}{24}$	$\frac{7}{24}$	...	Cast of left valve.

* These are noticed also by Count Keyserling in a species from Petschora-Land.

Valves most convex at the middle and somewhat posteriorly; the posterior half of the valve broadest and boldly rounded backwards and downwards. Old individuals less tapering anteriorly, and more oblong, than younger valves. Anterior and posterior angles of the dorsal edge prominent in well-preserved specimens, the extremities of the hinge-margin being truncate, and the anterior and posterior margins of the valves obliquely rounded off from beneath them.

Ventral margin of the right valve overlapping that of the left to the extent of about $\frac{1}{3}$ th the breadth of the carapace.

Dorsal margin of the left valve slightly thicker than that of the right, which latter is somewhat thickened only at its anterior third; ventral margin inverted suddenly, and marked with transverse striæ within and without.

Surface of each valve slightly depressed along a narrow area just within the margin, which forms a gently raised convex border, narrow on the dorsal edge, broader on the ventral.

Central spot and radiating canals well defined; the latter are seen, in the cast represented at fig. 4 *a*, to spring from a circular vascular impression, or sinus, surrounding the central spot or tubercle. The radiating canals have left only obscure traces on the cast* of the small specimen, fig. 5 *a*; which, however, shows the reticulated or warty appearance of the central tubercle very clearly. Anterior tubercle prominent, on an ill-defined slight elevation, which is bounded behind by a faint sulcus extending from the dorsal edge to the central tubercle.

The smaller cast, fig. 5 *a*, which I regard as representing a younger individual of this species, presents a broadish depressed margin on the anterior and ventral borders,—a feature that becomes almost obsolete in the adult specimens. It also bears a gently curved crenulated ridge, of slight elevation, crossing obliquely the postero-dorsal region of the valve;—this ridge is not traceable in the older specimen, fig. 4 *a*.

Surface smooth, shining; colour usually dark brown; two large, somewhat worn, odd valves in Mr. Morris's collection are light brown in colour; and in the largest the anterior tubercle is whitish, with a central black spot (fig. 1 *a*, *c*). In these two old individuals the surface exhibits traces of a fine punctation.

This species occurs in the Upper Silurian limestone of Gothland †, where it appears to be not uncommon. Hisinger gives the localities thus:—“In the Transition limestone of Gothland at Länna, near Slitehamn; also in detritus on the sea-shore: in brownish limestone in the Island Björkö, near Holmestrand,

* The surface of the cast is covered by very fine but obscure pittings, as if the inside of the valve had been marked by an ill-defined reticulation.

† For a notice of the geology and fossils of Gothland, see Quart. Journ. Geol. Soc. vol. iii. pp. 18, 30, &c.

Norway." Count Keyserling* states that this Gothland species occurs in the Silurian dolomitic limestone on the Waschkina, Petschora-Land, in company with another species (*Leperditia marginata*, Keyserl. sp.).

2. *Leperditia Arctica*, Jones. Pl. VII. figs. 1-5.

Leperditia Balthica, var. *Arctica*, Jones. Salter's Appendix to Sutherland's Journal of a Voyage in Baffin's Bay, &c., 1852, vol. ii. p. ccxxi. pl. 5. fig. 13; and Quart. Journ. Geol. Soc. vol. ix. p. 314.

Dimensions of closed or of separate valves of four individuals :—

Length. (inch)	Breadth. (inch)	Thickness. (inch)	
$\frac{1}{2}$	$\frac{1}{3}$	...	Right valve.
$\frac{1\frac{1}{4}}$	$\frac{7}{24}$	$\frac{5}{24}$	Perfect carapace.
$\frac{8}{24}$	$\frac{5}{24}$	...	Right valve.
$\frac{8}{24}$	$\frac{5}{24}$	...	Left valve.

Valves most convex near the centre, depressed near the margins; antero- and postero-dorsal angles strongly marked; the anterior extremity acute. Central portion of the ventral border of right valve projecting downwards with an almost angular outline (giving the carapace a subtriangular shape), and overlapping the left valve to the extent of $\frac{1}{4}$ th of the breadth of the carapace.

Dorsal edge of left valve much thicker than that of the right; the thickness greatest posteriorly.

Anterior and central tubercles well developed; the radiating vascular impressions form a delicate reticulation over nearly all the inner surface of the valves, and arise from a large groove or sinus surrounding the central tubercle. This circular sinus is connected by a still broader sinus with the raised area of the dorsal border of the valve. There is also another sinus embracing the under side of the anterior tubercle, and passing forward along the raised area in front of the tubercle to disappear at the antero-dorsal angle. From the lower side of this sinus fine vascular impressions originate, which freely inosculate with the others. On one specimen (fig. 1 *a*) the anterior tubercle is surrounded by a slightly raised, oval, crenulated border; and the surface of the valve immediately beneath the central tubercle distinctly exhibits by faint raised lines the course of the larger radiating canals.

Surface smooth and polished; colour light brown.

* "Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land." 4to, 1846, p. 289.

L. Arctica occurs abundantly in the Upper Silurian limestone at Cape Hotham in Assistance Bay, and Seal Island in Baring Bay; also in Griffiths and Cornwallis Islands. Specimens were brought to England by Dr. P. C. Sutherland.

This species (which at first, when Mr. Salter showed it to me in 1852, I was scarcely disposed to separate from the Gothland species) differs from *L. Balthica* in several points,—in its smaller size,—greater angularity of outline,—the greater convexity of the valves, and depression of their dorsal region,—the thickness of the dorsal edge of the left valve,—the great overlap of the right valve,—the greater delicacy and extent of the radiating canals,—and the lighter colour.

3. *Leperditia alta*, Conrad, sp. (?) Pl. VII. figs. 6 & 7.

Cytherina alta, Conrad, Report Geol. New York; Vanuxem, Geology of New York, 1842, p. 112. fig. 23, 6; Hall, Palæontology of New York, 1852, vol. ii. p. 338. pl. 78. fig. 2 *a, b, c*.

A specimen of hard, dark Upper Silurian limestone, containing numerous specimens of *Leperditia*, chiefly on a weathered plane of bedding, was brought to England from the shores of Wellington Channel* by Dr. P. C. Sutherland, and is now in the Museum of Practical Geology. The fossils are single valves, with their convex surfaces more or less exposed on the weathered surface, which also presents numbers of minute bodies, probably crustacean likewise. The valves are roughened by the irregular dissolution of their substance, and each has the most prominent spot of its convexity irregularly enamelled, as it were, by a local mineralogical condition of the altered calcareous matter of the fossil. The limestone affords a few specimens by fracture; these have smooth surfaces. The characters are as follow:—

Dimensions of separate valves of five individuals:—

Length. (inch)	Breadth. (inch)	
$\frac{5}{24}$	$\frac{3}{24}$	}
$\frac{1}{4}$	$\frac{1}{6}$	
$\frac{10}{24}$	$\frac{6}{24}$	
$\frac{9}{24}$	$\frac{6}{24}$	}
$\frac{11}{24}$	$\frac{7}{24}$	

Carapace-valves strongly convex, smooth, dark olive-brown in colour, more or less oblong, somewhat variable in outline, straight above, rounded below; extremities obliquely rounded; the dorsal angles in some much more definite than in others; posterior half broader and rounder than the anterior. Anterior

* Cape Riley or Becchey Island.

tubercle distinct, especially in the casts; central tubercle not distinct.

The anterior and posterior borders of the right valve present a slight marginal rim, especially in the younger specimens. A distinct but very narrow marginal rim is seen on the anterior, ventral, and posterior borders of some young left valves. The ventral margin of the right valve is thick and incurved, overlapping that of the opposite valve, which has its inner edge inverted at a somewhat acute angle; this inverted ventral plate is smooth.

Prof. Hall's figures, which he refers with doubt to "*C. alta*," agree in general contour with the form under notice; but the unworn surface of the latter is not papillose like the Schoharie specimens. Mr. Vanuxem's figures are wretched; but as Prof. Hall appears, after having examined specimens of the fossil indicated by Conrad and Vanuxem, to be disinclined to separate the two, it is quite possible that all may be referred to one species. Mr. Conrad* and Mr. Vanuxem quote the species as occurring in the Tentaculite limestone of the Waterlime group; Prof. Hall's specimens came from the Coralline limestone of Schoharie.

The Arctic specimens which I have here referred to *Leperditia alta*, although they differ in form less from *L. Balthica* than from *L. Arctica*, still do not present the characteristic obliquely-suboval outline of the former, but, the larger individuals at least, have a subglobose shape. Their marginal rim, though slight, is also a good distinctive character. In size they occasionally equal *L. Arctica*, but do not approach the magnitude of the Gothland specimens.

4. *Leperditia Britannica*, Rouault (?). Pl. VI. figs. 6 & 7.

Rouault, Bullet. Soc. Géol. France, deux. sér. 1851, vol. viii. p. 377, woodcut figs. 1, 2, 3.

Dimensions:—

Length.	Breadth.	
(inch)	(inch)	
$\frac{1}{2}\frac{1}{4}$	$\frac{7}{2}\frac{1}{4}$	(about). Bretagne specimen.
$\frac{1}{2}\frac{5}{4}$	$\frac{9}{2}\frac{1}{4}$	Normandy specimen: right valve.
$\frac{9}{2}\frac{1}{4}$	$\frac{5}{2}\frac{1}{4}$	Normandy specimen: right valve.

An odd dextral valve, apparently referable to the species indicated above, affords the following characters.

* Under the name of "*Cytherina fabulites*," Mr. Conrad has described (Philad. Acad. Nat. Sc. Proceed. vol. i. p. 332) a bivalve Entomostracan from the Trenton limestone of Mineral Point, Wisconsin, which from the description of its shape and size is probably a *Leperditia*.

Right valve nearly oblong, broadest and roundest behind; tapering and angular in front; most convex in the middle; depressed towards the margins, which are for the most part slightly raised; ventral border overlapping the opposite valve to the extent of $\frac{1}{4}$ th of the breadth of the carapace; anterior tubercle distinct; central spot not defined. Surface smooth, not polished; black.

Another, but smaller, right valve (younger individual) is similar in general form, but relatively shorter and broader.

These two specimens occur on a small fragment of dark, shelly, Devonian limestone from Néhou in Normandy, which has been kindly lent me by Mr. Morris.

It appears to me probable that they belong to M. Rouault's species (which is from the Devonian rocks of Brittany), although the latter form appears to differ in the degree of convexity, and to be shorter and broader in proportion, but unfortunately neither M. Rouault's specific description nor figures supply me with all the necessary terms of comparison.

The Normandy specimen, Pl. VI. fig. 6, differs from the right valve of *L. Balthica* in its narrower and more angular outline; in the greater depression of the surface towards the margins of the valve, or more rapid slope from the centre towards the periphery; and in the greater overlap of the ventral margin.

The vertical transverse section of the closed valves of *L. Britannica*, fig. 7, is copied from M. Rouault's memoir for the sake of comparison. The ventral overlap of the larger valve is considerable, as in fig. 6 *a*; but the convexity of that valve differs in the two individuals. The inverted plate of the ventral border of the smaller valve, as shown in fig. 7, may be remarked as being of very small extent, compared with that of *L. Balthica*, and of some of the species hereafter described. In M. Rouault's fig. 1, the small valve is seen to have a dorsal protuberance, like that in *L. gibbera* (Pl. VII. fig. 9 *a*); hence, if I am right in assigning the Normandy specimens to the Bretagne species, their left valve would have the dorsal hump,—another characteristic feature distinguishing them from *L. Balthica*.

5. *Leperditia gibbera*, nov. sp. Pl. VII. figs. 8–10.

Dimensions of the separate valves of four individuals:—

Length. (inch)	Breadth. (inch)	
$\frac{9}{24}$	$\frac{5}{24}$	Left valve.
$\frac{8}{24}$	$\frac{4}{24}$	Right valve.
$\frac{1}{4}$	$\frac{1}{8}$	Right and left valves.

Valves strongly convex; almost oblong, broadest at the pos-

terior third; extremities obliquely rounded; ventral margin gently curved; convexity greatest on the median line.

Extremities of right valve depressed and margined with a narrow flattened rim; ventral margin incurved, and but slightly overlapping the opposite valve.

Left valve thickened along the dorsal border, especially posteriorly, where it presents a smooth, oval, ridge-like protuberance, short and depressed in young specimens, but prominent and occupying even more than the middle third of the dorsal edge in old individuals. The protuberance is separated from the anterior tubercle by an oblique furrow. This dorsal protuberance is not present in the right valve at any age. The excessive thickening of the postero-dorsal portion of the left valve is also present in *M. Rouault's* Bretagne species*; and a tendency to this condition is indicated in *L. Arctica*, and very slightly in *L. Balthica*.

The rest of the border of the left valve is suddenly depressed into a narrow, flat, and trenchant marginal rim; the inverted ventral edge is narrow.

Anterior tubercle well marked; central tubercle indistinct. Surface of valves smooth, shining, finely pitted, and of a rich brown colour.

L. gibbera occurs in numbers in the Upper Silurian limestone of Beechey Island, in company with numbers of small bivalved Entomostraca, probably *Beyrichia*, among which are two varieties of *B. Klædeni*. Specimens of the limestone have been brought to England by Capt. Sir E. Belcher, and are now in the Museum of Practical Geology.

6. *Leperditia marginata*, Keyserling, sp. Pl. VII. figs. 11-14 & 15.

Cypridina marginata, Keyserling, Wissenschaftliche Beobachtungen auf einer Reise in das Petschora-Land (Geognostische Beobachtungen), 1846, p. 288. pl. 11. fig. 16.

Cypridina Balthica, Eichwald (non *Cytherina Balthica*, Hisinger), Bullet. Imp. Soc. Nat. Moscou, 1854, No. 1. p. 99. pl. 2. fig. 6.

A specimen of whitish (dolomitic) Upper Silurian limestone, containing numerous specimens of a small *Leperditia* (chiefly on a divisional plane of the rock), from the village of Saretche, in the Government of St. Petersburg, has been kindly presented to me by Mr. T. Davidson, who received it from Prof. Kutorga of St. Petersburg. It was labelled "*Cypridina marginata*, Key-

* Bullet. Soc. Géol. France, 2 sér. vol. viii. p. 377. fig. 1.

serl." The carapaces have mostly disappeared; but some remain in an altered crystalline state, or as a pulverulent, white, calcareous substance. The casts of the interior, and sometimes of the exterior, of the valves are very distinct; but the saccharoid crystalline character of the matrix has been ill adapted to receive the impression of any fine vascular or other markings, if such existed in the originals.

Casts of a right and a left valve are figured in Pl. VII. figs. 11, 12; and, having been able, in some instances, to observe portions of the carapace in place, as well as good casts of the outside, I am satisfied that the exteriors of the valves presented almost, if not quite, as strong a marginal rim as is seen in the casts. This I especially mention, because M. Eichwald, in describing* specimens of a similar form (possibly identical), from Esthland and Livonia, states that the outsides of the valve have no marginal sulcus and rim, and that the casts alone exhibit this character.

The St. Petersburg specimens present the following characters:—

	(inch)	(inch)
Dimensions:—Length	$\frac{1}{4}$	to $\frac{7}{24}$
Breadth	$\frac{1}{6}$	to $\frac{5}{24}$

Carapace-valves almost equivalve, nearly oblong (subject to slight variation in outline), broadest at the posterior third, straight at the back, obliquely curved on the ventral margin, and obliquely rounded at the extremities; the convexity of the surface is nearly central. The central portion of the ventral edge of each valve is somewhat incurved; that of the right valve apparently overlapping that of the left.

The right valve is margined, except on the dorsal edge, by a well-marked sulcus, running along at a short distance from the edge, and separating off a narrow, flattened, or slightly convex border. On the left valve there is a similar marginal rim, but it dies out on the central incurved portion of the ventral margin, fig. 12 *b*.

The anterior tubercle is distinct; the central tubercle can also be easily discerned on the casts; the radiating vascular markings, however, are not apparent.

Of M. Keyserling's figures of *Leperditia marginata* (*op. cit.*), fig. 16 *d* (the smallest figure) alone corresponds exactly with the form under notice; in fig. 16 *b* (*op. cit.*), and apparently in fig. 16 *a*, the marginal rim (of right valve) is indicated as passing round

* Moscow Bulletin, 1854.

the ventral margin as a projecting edge*, keeping the vertical direction of the valve, instead of being a mere moulding accompanying an incurvation of the ventral border. Further, in fig. 16 c (*op. cit.*), there is represented an inverted edge to the right† valve (as in the left valve of *L. Balthica*); and Count Keyserling remarks, that, whilst the ventral plate in *L. Balthica* is marked with transverse striæ, in this species it is smooth.

The *Petschora* specimens vary from about $\frac{5}{24}$ to $\frac{5}{24}$ inch, and even reach nearly $1\frac{1}{4}$ inch, in length.

The anterior and the central tubercle are both referred to by M. Keyserling as being well marked in *L. marginata*, and the cast of the inside of the central tubercle is described as being beset with crowded unequal wart-like markings, and accompanied by ill-defined, tortuous, fine vein-markings, radiating backwards. The sulcus defining the marginal ledge is stated to be "slight on the surface of the valves, and deepened on the cast."

M. Eichwald‡ describes and figures a form under the denomination of "*Cypridina Balthica*," and at the same time recognizes in the casts, at least, the "margins" seen in Keyserling's species, and apparently allows the latter species to be well established on that character. The individuals of M. Eichwald's species vary in length from $\frac{1}{8}$ to $\frac{1}{6}$ inch (according to his figures); and in the text he gives " $\frac{1}{2}$ inch" as the size. They possess the anterior and central tubercles, with the muscular impression and radiating vascular markings. Excepting that the outside, according to the author, exhibits no marginal sulcus and rim, though the internal cast does, M. Eichwald's figures present no material differences from the smaller form of M. Keyserling's species. Neither the figures, however, nor the description, afford all the necessary details for satisfactory comparison with known species.

The specimens here referred to are from "the upper beds of the greywacke limestone" of Esthland and Livonia; and, according to M. Eichwald (*op. cit.*), another similar form, but with a row of punctiform pits on the border of the valve [query, on a depressed marginal border?], and without any apparent central spot and radiating vessels, occurs in the dolomitic limestone near Gatschina, on the river Oredesch §.

* It is described as "more or less clearly running along all the oval outline of the valve and ending at the hinge-angles."

† As this inversion on the right valve is contrary to what obtains in other species of the genus, perhaps this figure has been reversed on the plate.

‡ Bulletin Imp. Soc. Nat. Moscou, 1854, part 1. p. 99. pl. 2. figs. 7 & 8.

§ M. Eichwald also figures and describes a narrower and slightly arched form ("*Cypridina minuta*," *loc. cit.* fig. 6), from the Brandschiefer of Erras and the vicinity of Talkhof.

In Plate VII. fig. 14, I have figured a very interesting specimen, which apparently is referable to the larger form of Count Keyserling's species (*loc. cit.* fig. 6 *a* to *c*). It is in a white (dolomitic) Silurian limestone, brought by Sir John Richardson from Pine Island Lake* on the English or Great River, a few miles north of Cumberland House (about lat. 54°, long. 104°), and is now in the British Museum.

The fossil represents in relief the interior of a single left carapace-valve, and appears to have been a cast which, subsequently to the removal of the valve itself, has been smoothly recoated to a certain extent with a thin covering, similar in colour to the matrix, but less crystalline. In some aspects, the edge of the cast being partially non-continuous with the matrix, the fossil has an appearance of representing the valve itself,—which is not the case.

It is $\frac{3}{4}$ inch in length and $\frac{1}{2}\frac{1}{4}$ inch in breadth; similar to some specimens of *L. Balthica* in its obliquely suboval outline and well-defined dorsal angles; the surface is strongly convex, sloping gradually posteriorly, but suddenly depressed on the anterior and ventral margins to meet a well-defined flat marginal rim, which ends at the extremities of the dorsal border.

Anterior tubercle very distinct, surrounded by an irregular depression; central tubercle large, but not elevated; radiating vascular markings not apparent; an oblique shallow furrow, passing from the depression behind the anterior and above the central tubercle to the most projecting portion of the posterior portion of the valve, cuts off a somewhat raised area along the postero-dorsal region.

If there be any inverted plate within the ventral border (like that represented in Keyserling's fig. 16 *c*, *op. cit.*), it is concealed by the matrix.

I follow M. Keyserling in placing two such apparently dissimilar forms as figs. 11–14 under one specific appellation, because my own materials for observation are very limited, and it is possible that the Petschora-Land specimens have afforded the necessary links for connecting the two by specimens of different stages of growth.

If the smaller form (figs. 11, 12) be the young of the larger one, we have a carapace with a merely moulded and incurved ventral edge in its young form developing a strongly bordered margin with an inverted ventral plate (according to Keyserling, *op. cit.*) in its older state! If, on the contrary, as I am inclined to suspect, the smaller form be an adult, it is necessarily distinct,

* Journal of a Boat-Voyage through Rupert's Land, &c. 2 vols. 8vo. London, 1851 (vol. i. p. 75).

and does not come within the typical group of *Leperditia*, and should be removed to a subgenus at least.

It should be remarked that *L. marginata*, as represented by figs. 11–14 (and M. Keyserling's figures), differs from *L. Balthica*, and the other species above mentioned, in having the greatest convexity on the anterior and inferior region of the valve, rather than on the central portion.

Fig. 15 represents a cast in sandstone ($\times 2$ diam.), from the Tilestones (Downton sandstone) of Kington in Herefordshire, of a *Leperditia* apparently belonging to the species under notice. It is associated with casts of small *Lingulae*. Another specimen, consisting of a cast of the left valve, in the same sandstone, exhibits similar characters.

These individuals measure $\frac{7}{8}$ inch in length, and $\frac{1}{6}$ inch in breadth; they are rather more angular anteriorly than figs. 11 & 12; they present only obscure traces of a marginal rim; and their dorsal edge is not quite straight, but very slightly raised at the centre. Otherwise the general form is similar in the English and Russian specimens.

The anterior and central tubercles in the Kington specimens are distinctly seen, and have the same relative position and proportions as in the St. Petersburg specimens.

With all the slight differences observable, considering the indifferent state of the casts, I do not think that the Kington specimens can be referred to any other than the Russian species.

This is the first noticed occurrence of *Leperditia* in British rocks*. The specimens are in the Museum of Practical Geology; and I am indebted to Mr. Salter for having kindly drawn my attention to them.

7. *Leperditia Solvensis*, nov. sp. Pl. VII. fig. 16.

Length $\frac{1}{8}$ inch; breadth $\frac{1}{14}$ inch.

The impression of the outside of a small valve (an artificial cast of which is represented, magnified 2 diameters, by fig. 16) on a fragment of Lower Silurian schist from South Wales has been kindly communicated to me by Mr. Salter. It is from the Llandeilo flags (lowest portion) of Upper Solva, Solva Harbour, St. David's; and is now in the Museum of Practical Geology.

The valve was slightly convex†, narrow oblong in shape, nar-

* Count Keyserling, in his remarks on the *L. marginata* of Petschora-land, expressed his astonishment that the Upper Silurian rocks of England had not yet yielded this species; as it has at last made its appearance, we may hope that it will soon be represented by numerous specimens in the cabinets of the indefatigable collectors in Siluria.

† The degree of convexity of the valve cannot be exactly ascertained, as

rower at one end than at the other, straight at the back, rounded at the ends, gently curved below. Excepting at the dorsal edge, there is a well-defined, flattened, marginal rim. The tubercles are not apparent.

This fossil approaches very nearly in outline to *L. gibbera*, and in some of its characters to *L. marginata*; but its small size, slight convexity, narrowness of shape, and large proportion of marginal rim separate it from these species.

Observations on the Genus.

I must first observe that Prof. Quekett, having microscopically examined portions of the carapace-valves of *Leperditia Arctica*, informs me that they exhibit most distinctly characteristic crustacean structure.

In seeking for the family alliances of this palæozoic genus, we find some of the characters of its carapace among the existing bivalved Entomostraca, both of the Phyllopod and Lophyropod groups; but others of its peculiarities are not yet traced. It is not well represented by any known recent form, but partakes of the characters of several.

Shape.—The carapaces and carapace-valves figured in Plates VI. & VII. present a general uniformity of shape, in the sub-oval outline on three of their edges and the straightness of their upper or dorsal border. They all possess the antero-dorsal tubercle, and most of them show some evidence of the central spot or tubercle. The ventral edge of the left valve is suddenly inflected to a greater or less extent in all excepting those referred to *L. marginata* and *L. Solvensis*. In the smaller form of the one (Pl. VII. fig. 12) there is a decided modification of the inflection alluded to;—in the latter, and in our large form of *L. marginata*, the evidence on this point is imperfect.

The mode in which the two valves close one on the other, by a strong overlap and an inflected flange, is peculiar to the typical *Leperditia*.

With respect to the form of the valves among other bivalved Entomostraca, fossil and recent, an approach to the outline-shape of *Leperditia* is not uncommon; but, except among the *Beyrichiæ*, few species are definitely characterized by this exact shape, with its dorsal angles and ventral curvature*. Those that approach most nearly in this outline of the carapace-valve are the *Limnadidæ*† and (with the exception of being notched) some of the *Cypridininaæ*.

its convex portion has been somewhat crumpled by pressure; in other respects the original form appears to be well preserved.

* *Cypridina Isabella* is one of the few examples of this shape (here modified by an infero-anterior notch) in other genera.

† Especially in the young state.

Central spot.—There is another point of resemblance between *Leperditia* and the *Limnadiidæ*, namely the great central spot with its vascular markings (Pl. VI. fig. 1 *c*; Pl. VII. fig. 4 *d*). In *Leperditia* there appears to be only one circular canal; in *Isaura* (*Estheria*) *cycladoides* there are three (Joly*), as there are also in *Lymnetis*, as shown by Grube†. These concentric vascular impressions on the inside of the carapace are present also in other Entomostraca, as for instance, on the lateral halves of the carapace in *Apus*‡ and *Lepidurus*§.

The reticulated centre of this spot (which leaves the low warty tubercle on the casts of the fossil valves) is the place of attachment for the great adductor muscle of the animal|| (Joly, Grube).

The radiating canals, originating at the central tubercle, are found in *Lymnetis* (Grube, *loc. cit.*) as well as in *Leperditia*.

The concentric, radiating, and reticulate markings are probably referable to the course of blood-vessels and sinuses. The carapace of many of these little Crustaceans appears to be extremely sanguiferous, and an important adjunct to the usual respiratory organs.

The central spot of *Leperditia* and the *Limnadiidæ* is represented in the *Cypridininae*, *Cyprinae*, and *Cytherinae* by a group of variously arranged minute lucid spots, occupying an analogous position on the valve; and, in the first-named family at least, I believe the lucid spots certainly to mark the place of muscular attachment.

Eye-spot.—The anterior tubercle may with probability be regarded as indicating the place of the eye¶,—or possibly even as the external part of that organ; but, excepting some allied palæozoic forms, there are no other bivalved Entomostracans having the eye indicated by a tubercle on the carapace, and few have the eye placed so high up in the antero-dorsal region.

In the *Cyprinae* and *Cytherinae* the eye is single (coalesced), and close up to the anterior hinge. Some at least of the *Cypridininae*, in which group the eyes are separate and transversely distant one from another, have the eyes lower down in the an-

* Annal. Sc. Nat. 1842, nouv. sér. vol. xvii. p. 293 &c. pl. 7-9.

† Bemerkungen über die Phyllopoden, &c., von Dr. A. E. Grube; Archiv für Naturgeschichte, 1853, p. 109. pl. 7. fig. 22.

‡ Baird's Natural History of the British Entomostraca (Ray Soc.), 1850.

§ Baird, Zool. Soc. Illust. Proceed. 1850. Annulosa, pl. 17.

|| This central tubercle in the fossil Entomostraca has been often mistaken by palæontologists for an eye-spot. Eichwald (*loc. cit. supra*) supposes it in *Leperditia* to be the seat of the ovary, and the associated radiations to be ovarian vessels: this is quite untenable; the eggs are found in the postero-dorsal region of the recent bivalved Entomostraca.

¶ Count Keyserling (*loc. cit. supra*) describes this tubercle in *L. marginata* and *L. Balthica* as the "eye-tubercle."

tero-dorsal region,—just above and in front of the muscle and central spot*. This last is the position of the eye-tubercles in *Leperditia*.

In the *Limnadidæ* the eyes are quite differently situated. They are closely approximate, and are placed (as in the *Daphnidæ*) low down on the beaked head (or cephalic rostral buckler) of the animal; and hence they are sometimes even protruded from between the anterior margins of the valves in *Estheria*.

The eye-spots or anterior tubercles of *Leperditia*, being near the dorsal edges of its carapace, have an analogous position to that of the eyes on either side of the mesial line of the horizontal carapace in the *Apodidæ*,—or rather, being somewhat further apart (measuring across the hinge-line of the valves), those of *Corycæus* and *Caligus*.

Conclusion.—The points of resemblance between the carapace of members of the recent families of Entomostraca and that of *Leperditia* may be indicated as follows:—

Resemblance in—	<i>Limnadidæ.</i>	<i>Cypridininaæ.</i>	<i>Apodidæ.</i>
Outline	+	*	—
Central spot for muscular attachment	+	+	—
Vascular markings (sinuses)	+	—	+
Vascular markings (radiating)	+	—	—
Situation of the eyes	—	+	*
Eye-tubercles	—	—	+

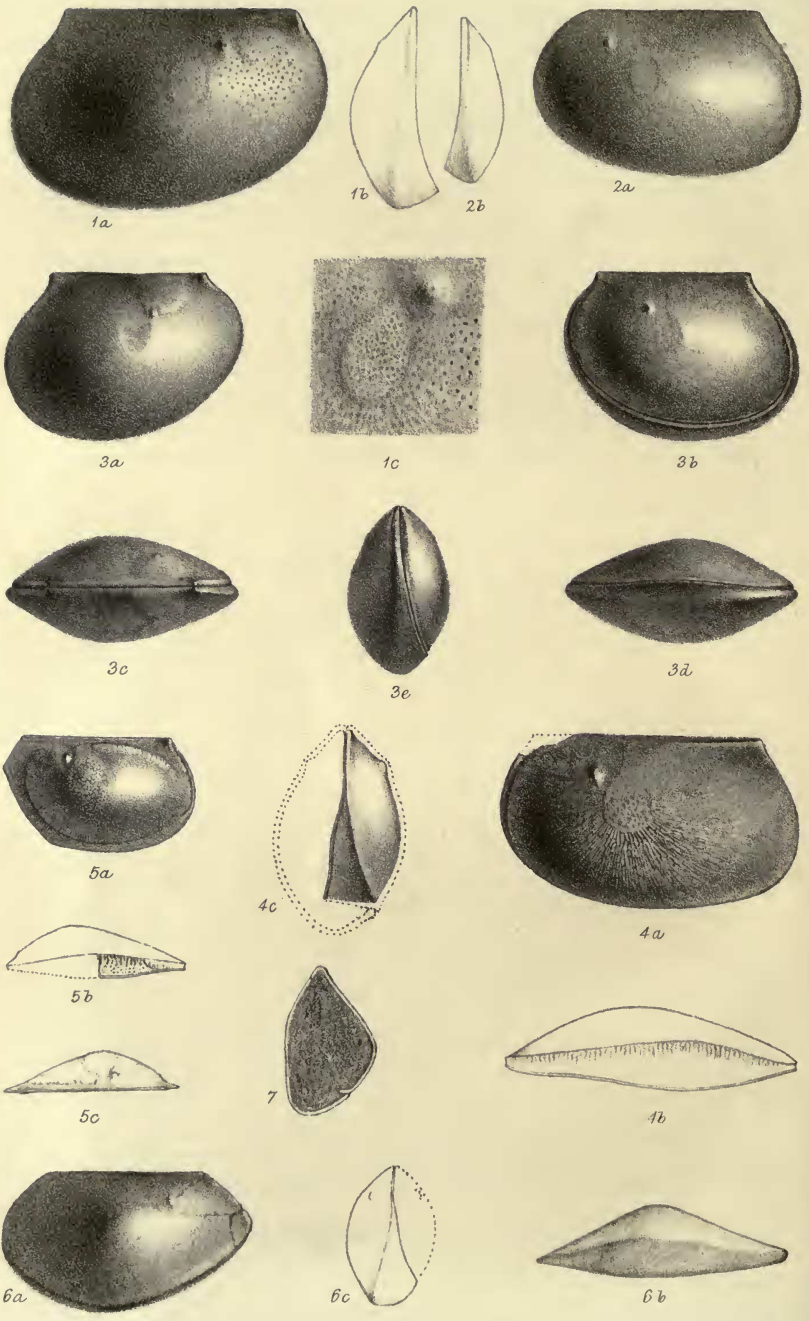
The above remarks may be of use not only in showing the difficulty that exists in co-ordinating this fossil genus (so far as the remains of the carapace will help us) with its known allies, but also to some extent in illustrating another example “of the combination in extinct animals of characters separately manifested in existing species.”

In concluding this notice of the relations of *Leperditia*, I would observe that the successive changes in the developmental growth of individuals remind us of the gradations of structure observable among allied species; and, as among the *Limnadidæ*, young individuals † present not a bivalved, but an horizontal carapace, like that of *Apus*, so the carapace of an Apodoid ideally folded in two along its mesial line, with its two halves drawn together by a transverse muscle, would well represent in most of its important characters the carapace of a *Leperditia*; for the eye-spots would be nearly in the relative position required, and the central muscle-spot would be associated with vascular mark-

* For instance, *Cypridina Zealandica*.

† *Estheria* and *Lymnetis*, less than a week old: (Joly, Grube).





C.C. Sowerby del. G. West lith.

Ford & West Imp.

Palaeozoic Entomostraca. LEPERDITIA.

ings. Nor would the valves, thus ideally constructed, be without considerable resemblance in outline to the *Leperditia* valves. Moreover, the vertical dorsal sulcus, which is scarcely apparent in the typical *Leperditia*, though strongly marked in another section of the group, and present also in *Beyrichia*, would find its homologue in the nuchal furrow of the folded Apodoid.

Burmeister*, in his review of the classification of the fossil Entomostraca, observed that Hisinger's two Gothland species (together with Klöden's *C. phaseolus*) should be regarded as belonging to a group distinct from the *Cytheres*. He proposed to retain the generic term *Cytherina* † for them, and to found on them a distinct family (*Cytherinidae*) of the *Phyllopoda*; referring to *Estheria* as a closely allied genus. Keyserling and Eichwald quote *L. Balthica* as a "Cypridina."

There can be little doubt that *Leperditia* and its allies are sufficiently distinct from the known Entomostracan groups to constitute a separate family, as Burmeister recommended. The *Leperditidae* (as I propose to term this group), comprising *Leperditia*, *Beyrichia*, and some other forms not yet described, may be regarded as most probably coming within the pale of the *Phyllopoda*.

EXPLANATION OF PLATES VI. AND VII.

PLATE VI.

[The figures (excepting fig. 1 c) represent the specimens magnified two diameters.]

Fig. 1. *Leperditia Balthica*: *a*, right valve; *b*, the same, anterior extremity; *c*, the same, central spot and anterior tubercle, highly magnified.—From Mr. Morris's Cabinet.

Fig. 2. *Leperditia Balthica*: *a*, left valve; *b*, the same, anterior extremity. [This specimen being somewhat worn, does not well show the sharp angle of the ventral edge.]—From Mr. Morris's Cabinet.

Fig. 3. *Leperditia Balthica*: *a*, perfect carapace, showing the right valve; *b*, the same, showing the left valve; *c*, the same, showing the dorsal aspect; *d*, the same, showing the ventral aspect; *e*, the same, showing the anterior extremity.—Mr. Morris's Cabinet.

Fig. 4. *Leperditia Balthica*: *a*, cast of the interior of a left valve, showing the anterior and central tubercles, and the radiating vascular markings; *b*, the same, ventral aspect; *c*, the same, showing the anterior extremity. The dotted lines represent an ideal section of the carapace.—Museum of the Geological Society.

Fig. 5. *Leperditia Balthica*: *a*, cast of the interior of a left valve of a

* Organiz. d. Trilob. pp. 57 & 63. (Ray edit. pp. 49 & 55.)

† The name "Cytherina" was substituted by Lamarck for Müller's *Cythere*, and has been used by numerous writers in the same sense. Although "Cythere" has been restored to its original use, and the word "Cytherina" is adrift, still, from the frequent misuse of the latter term, it is not eligible as a generic appellation. Dana has lately used the term "Cytherinae" to represent a subfamily.